



5.4.8 Monsoon

History

Monsoon is an Arabic word meaning a seasonal wind shift. In Arizona, the wintertime precipitation is caused by cold fronts brought into the State from the west and northwest by westerly winds. In the summertime, the subtropical high pressure system moves northeast from the eastern Pacific Ocean and sets-up near the four-corners intersection of Colorado, Utah, Arizona and New Mexico, causing the predominant windflow to become southerly or southeasterly. This shift brings moisture northward from Mexico and the Gulf of California, resulting in near-daily convective thunderstorm activity across the State. Although the North American Monsoon has been studied intensively since the mid-1960s, forecasting the occurrence of the thunderstorms in the lower deserts of central and southwestern Arizona has proven to be extremely difficult. In the higher elevations, the thunderstorms occur almost daily for periods of 7 to 10 days, followed by 3- to 7-day breaks in activity.

The hazards associated with the monsoon in Arizona include severe thunderstorms, microbursts, high winds, lightning, heavy rainfall and flash flooding. The thunderstorms associated with the monsoon contain copious amounts of moisture which frequently causes torrential rainfall in a localized area over a short period of time. In the mountainous terrain of Arizona, the high rainfall rates, coupled with steep slopes, lead to flash flooding of normally dry washes. The washes drain into channels and eventually into the rivers that typically have relatively low flows, and the rivers are generally able to handle the additional water from a single storm. Although individual storms are generally responsible for significant property damage, injuries and deaths, occasionally a series of storms on consecutive days can saturate the ground and lead to widespread flooding of rivers. A recent example of a monsoon event in Arizona is:

July 25, 2006, a continual series of potent thunderstorms, spawning hail, damaging winds and flash floods affected many locations in southeastern Arizona causing more than \$11 million in damages. The damages included the destruction of roadways and bridges and electrical and water utility systems in some areas. As a result, many neighborhoods were isolated, making evacuations difficult. Due to The storms' extraordinary amount of rainfall resulted in flooding that exceeded historic levels. These storms resulted in a federal disaster declaration for the following counties: Gila, Graham, Greenlee, Navajo, Pima and Pinal. The Indian tribes included in the declaration were Gila River Indian Comm., Hopi Tribe, Navajo Nation, the San Carlos Apache Tribe and Tohono O'odham Nation (ADEM, 2006).

Map 28

In the development of this map, it was difficult to recognize Monsoon as a hazard and secondly, convey the concept of the monsoon season. As defined in the "Model Local Hazard Mitigation Plan", a monsoon is any wind that reverses its direction seasonally. In the Southwestern U.S., for most of the year the winds blow from the west/northwest. Arizona is located on the fringe of the Mexican Monsoon which during the summer months turns the winds to a more south/southeast direction and brings moisture from the Pacific Ocean, Gulf of California, and Gulf of Mexico. This moisture often leads to thunderstorms in the higher mountains and Mogollon Rim, with air cooled from these storms often moving from the high country to the deserts, leading to further thunderstorm activity in the desert. A common misuse of the term monsoon is to refer to individual thunderstorms as monsoons.

With that in consideration, we used data from the National Weather Service Monitoring Stations which included: station ID number, station name, latitude, longitude (decimal degrees) and average # of summer wetdays - which is an indication of the risk of monsoon. More raindays, more monsoon activity. These are calculated for the period of record for each station, through 2006.

In the creation of the map we used a process call "Triangulated Irregular Networks or TINs. This process uses # of raindays of three closest weather stations to create an area of average numerical representation and repeated for a statewide coverage. Then, this statewide coverage of a TIN uses a process called "Natural Neighbor" to interpolate and create a raster/polygon map representation of the # of rain days to identify the areas at risk by the monsoon season.

An increase in risk and # rain days, is in the SE and the mountains, especially the White Mountains and Mogollon Rim, including Flagstaff, Payson and Prescott. Lowest risk is Yuma and lower Colorado River.



Probability and Magnitude

Sabino Creek in Tucson had the highest flows in 60 years, and Rillito Creek had the highest flows in 90 years, according to the United State Geological Survey (USGS) in Tucson. During the last 2 days of the event, the Pima County Flood Control District reported that they had a 1000-year interval return period event, and over a 4-day period, they had a 200-year return interval event. Unfortunately, the occurrence of a 200-year or 1000-year event does not imply that the next event will not occur for another 200 or 1000 years. With the climate models predicting increased variability of both temperature and precipitation, the return interval of this type of event is difficult to estimate. In addition, the current drought conditions exacerbate the problem due to the increased occurrence of wildfires, which destroy vegetation that helps to slow down the run-off from heavy rain events. Return periods are calculated using the NOAA Atlas 14 point precipitation frequency estimates from the NOAA Hydrometeorological Design Studies Center.

Since the monsoon hazard is generally a result of recurrent rainfall over multiple days, often consecutive, the monsoon hazard map was generated using the average number of raindays during the monsoon season, based on the 1970-2006 period of record. Since the moisture source is generally Mexico, and thunderstorms typically form first in the higher elevations, the areas with the most monsoon activity are the higher elevations of the White Mountains in the east, the Mogollon Rim, and the southeastern mountains. These areas average 25-50 monsoon activity days, while the lower desert areas have fewer active days. It is important to remember that the number of days is out of an average 60 day season. Metropolitan Phoenix averaged 16 days out of an average 54 day monsoon season. The most was 29 days in 1984. Also, damage from the monsoon, in the form of flash flooding, will occur downstream of the precipitation areas, so the areas at risk are somewhat broader than the map contours indicate.

In an attempt to categorize the probability of future monsoon events, the hazard was analyzed using the CPRI. This method also takes into account the levels of magnitude/severity, warning time and duration. In Arizona, monsoons are highly likely, the magnitude/severity is typically limited, the warning time can be 6 – 12 hours and the duration is usually less than 6 hours. These factors resulted in a CPRI rating of 2.95. The highest rating a hazard can result in using this method is 4.

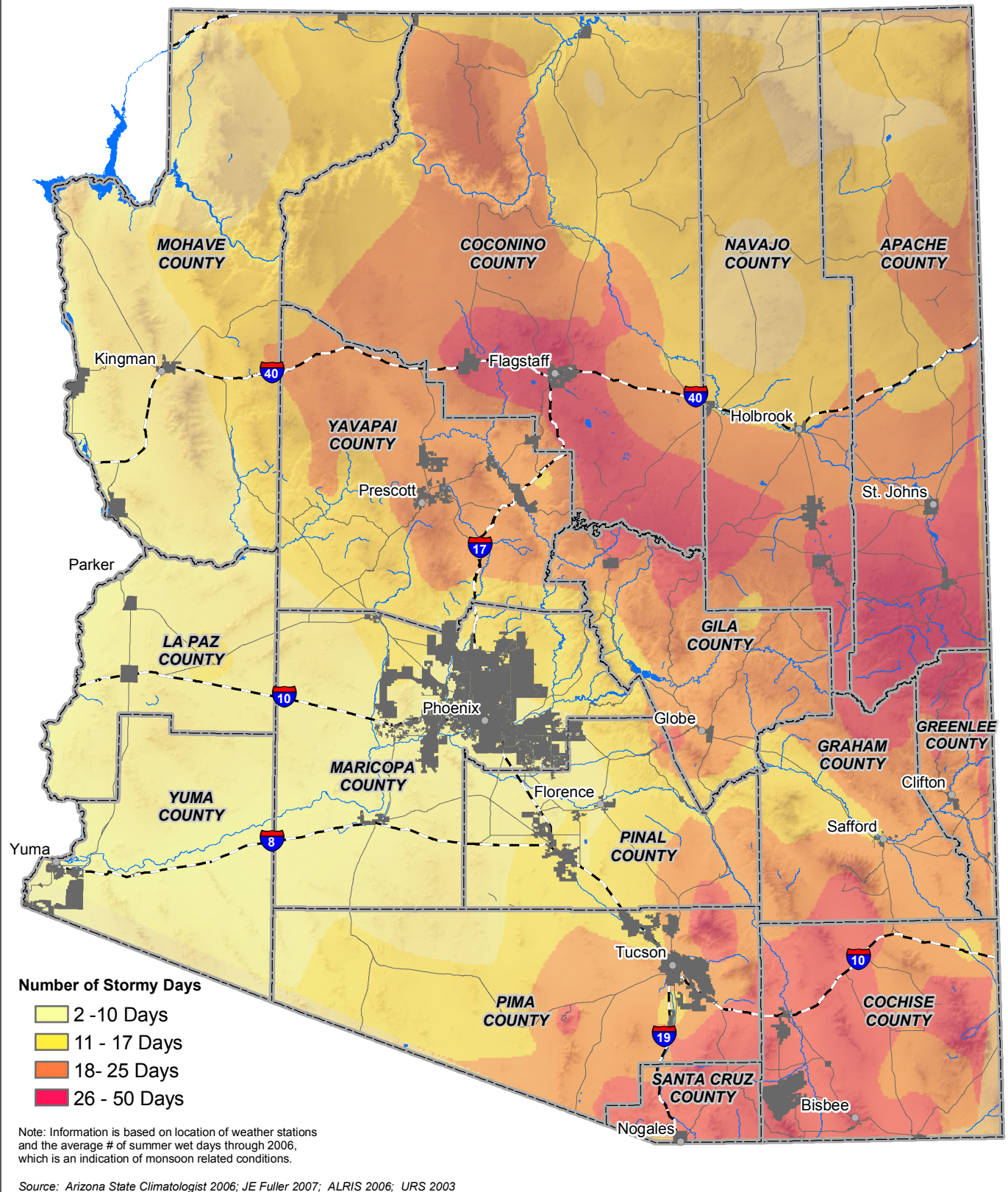
Vulnerability

The entire State is equally exposed to effects of monsoon related weather conditions during the summer months. During this time, monsoon related storm events may effect the higher regions with more rainfall, but the lower laying areas will ultimately be impacted by rainfall received, and the volume of rainfall from higher elevations; along with the repetitive nature of monsoon contribute to the effect of saturation rate of soils which results in more extensive flooding. The impact of this type of storm event can continue to be summarized by flooding/flash flooding and thunderstorm/high winds.

Sources:

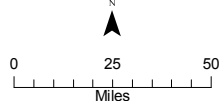
NOAA Hydrometeorological Design Studies Center (http://hdsc.nws.noaa.gov/hdsc/pfds/sa/az_pfds.html).

State of Arizona



Legend

- Major City
- County
- interstate
- Lakes
- Highway
- Cities
- Major Streams



August 2007



State of Arizona Multi-Hazard Mitigation Plan

Map 28

Average Annual Days of Storm Activity During the Monsoon

as of 2007

